L1 RCT Rates at $\mathcal{L}=2\times10^{33}$

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- **New CMS Internal note ready to be published:**
  - Supersedes CMS IN-2001/042
  - **http://cmsdoc.cern.ch/~pamc/Trigger2e33-03-02.pdf**
- **Uses data generated at 2×10^{33} cm^{-2} s^{-1}**
- **Calculated proper weights for the event**
- **Explored effects on physics efficiencies and rates for 8 different level-1 scenarios**

Simulation Introduction

Rates at LHC Turn On

- **Rates were calculated using 2×10^{33} data**
- **nTuples generated using FNAL production data**
- ***Weighted properly* - improved over previous note** CMS IN-2001/042
  - p_T's of main event and pileup not available for TDR analysis/previous note
- **No threshold increases for missing E_T and total E_T**
- **QCD data produced at FNAL**
  - Proper 3.5 events of pileup
  - Newer versions of CMSIM and ORCA
- **More than 350,000 events in L1 Calo nTuples**
- **HLT p_T bins from 10-1000 GeV used**
- **One simulation run (500 events in >350,000) in the 30-50 GeV bin was excluded because of large unphysical values of Missing E_T**

Latest algorithms

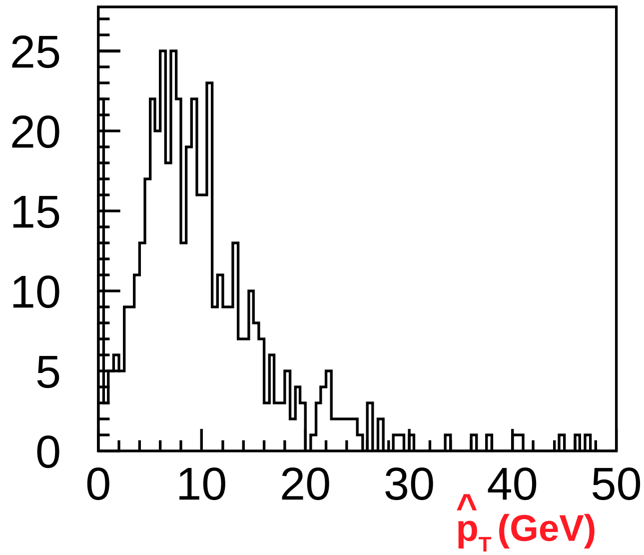
- **Jet algorithm: A programmable threshold cut is now applied to the center region of the 9 (3x3) regions.**
- **τ algorithm is updated to use new pattern algorithm**
- **Rates for new H_T Trigger - see following slides**

Calculation of the proper weight

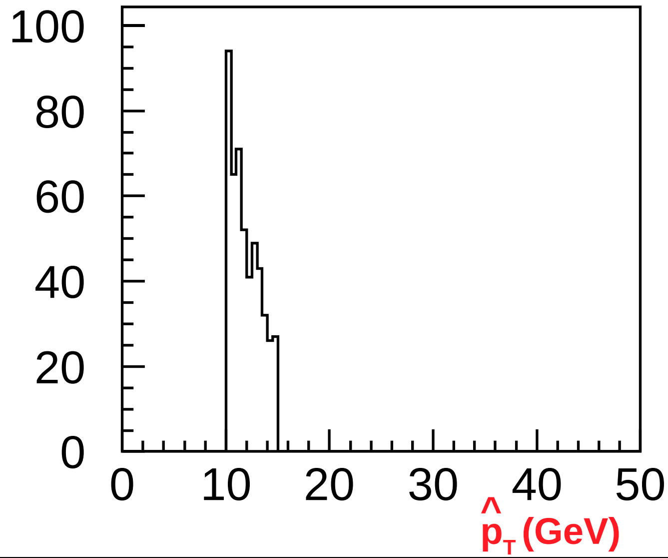
The problem:

- pileup events sometimes have a larger $\hat{p}_T$ than the actual "Physics" event in the QCD sample
- weight needs to take this into account
- Weight = $32\times10^3\mu \div \sum_{j=1}^{N_{bin}} N_j(n_j/f_j)$ (Branson and Trepagnier)
- Use pileup $\hat{p}_T$'s from bunch crossing "0".

Highest Energy Pileup Event



Physics Event

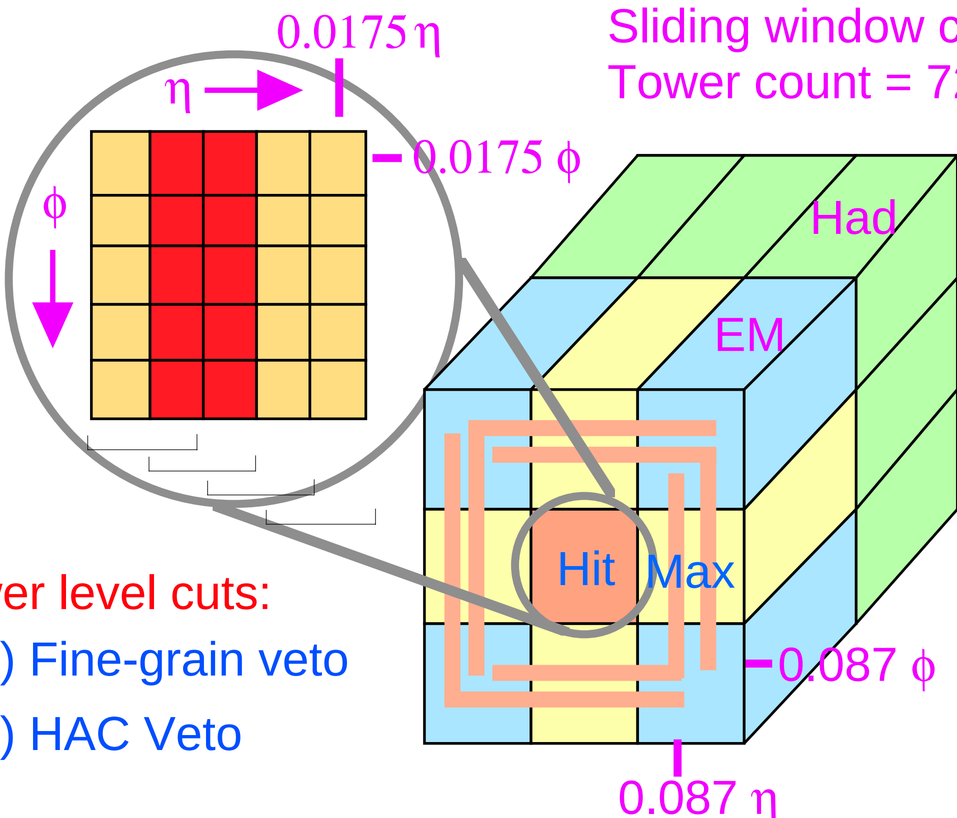


Clearly, some events' pileup has higher $\hat{p}_T$ than the physics event

(10-15 GeV bin - 500 events)

e/γ Algorithm - unchanged

Sliding window covering all η–φ plane
Tower count = 72φ x 56η x 2 = 8064



Candidate Energy:

Max — Max E_t of 4 Neighbors

Hit — Hit + Max E_t > Threshold

Tower level cuts:

1) Fine-grain veto
2) HAC Veto

Isolation Cuts:

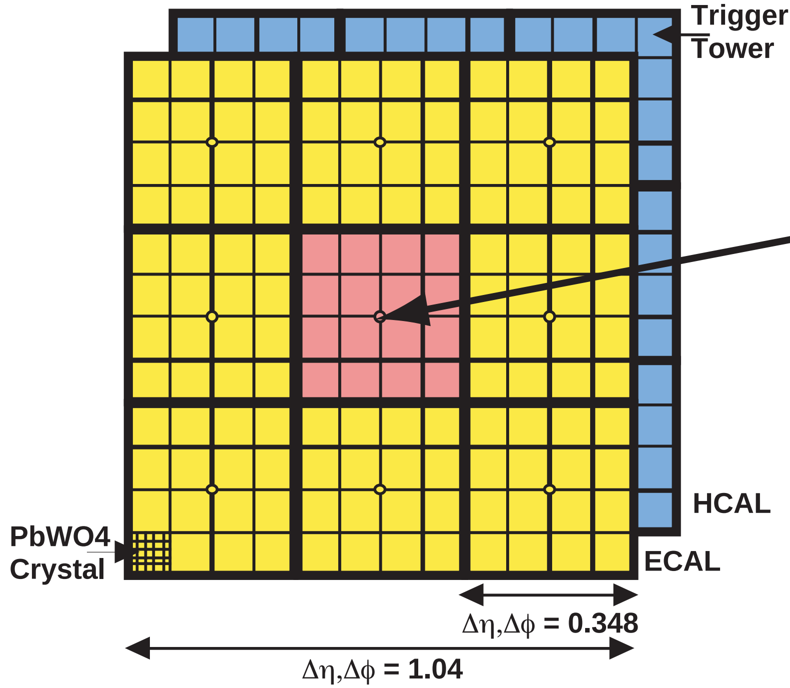
3) Neighbor FG/HAC Veto
4) Neighbor EM E_t Veto

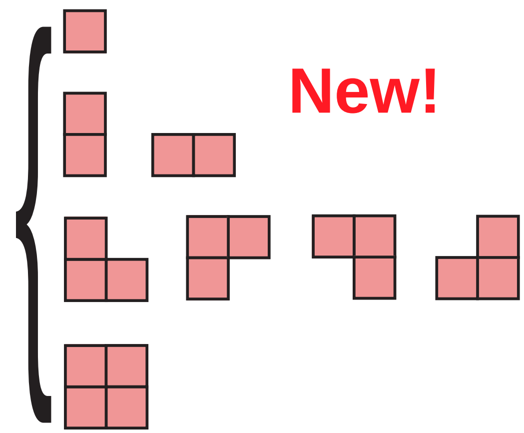
Summary:

Sort over all (η,φ) plane to find top-4 isolated and non-isolated candidates separately.

Jet/τ Algorithm

Input from E/HCAL: Programmable 8-bit nonlinear scale converted to 10-bit linear scale for sums to obtain jet E_T





τ-veto bit formed by requiring a single contiguous group of less than four active towers in each 4x4 region

Jet or τ E_T

- 12x12 trigger tower E_T sums in 4x4 region steps with central region > others,
- *central region above a programmable threshold (5 GeV for this study)*.

τ algorithm

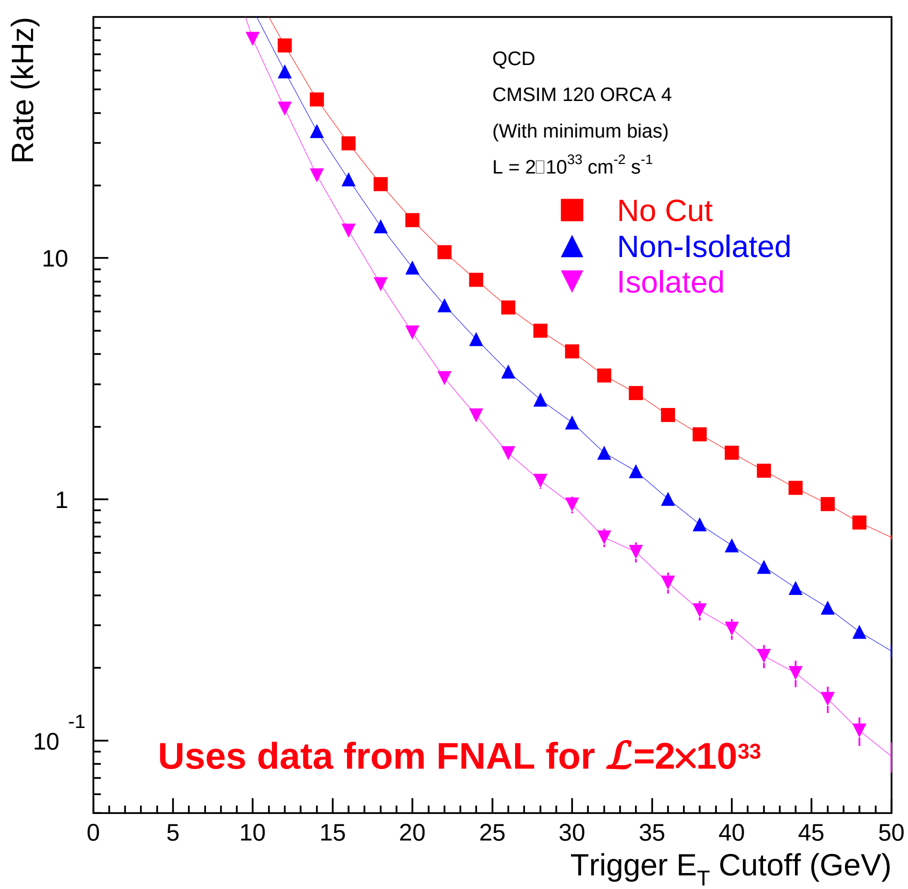
- redefine jet as τ-jet if none of the nine 4x4 region τ-veto bits are on

Output

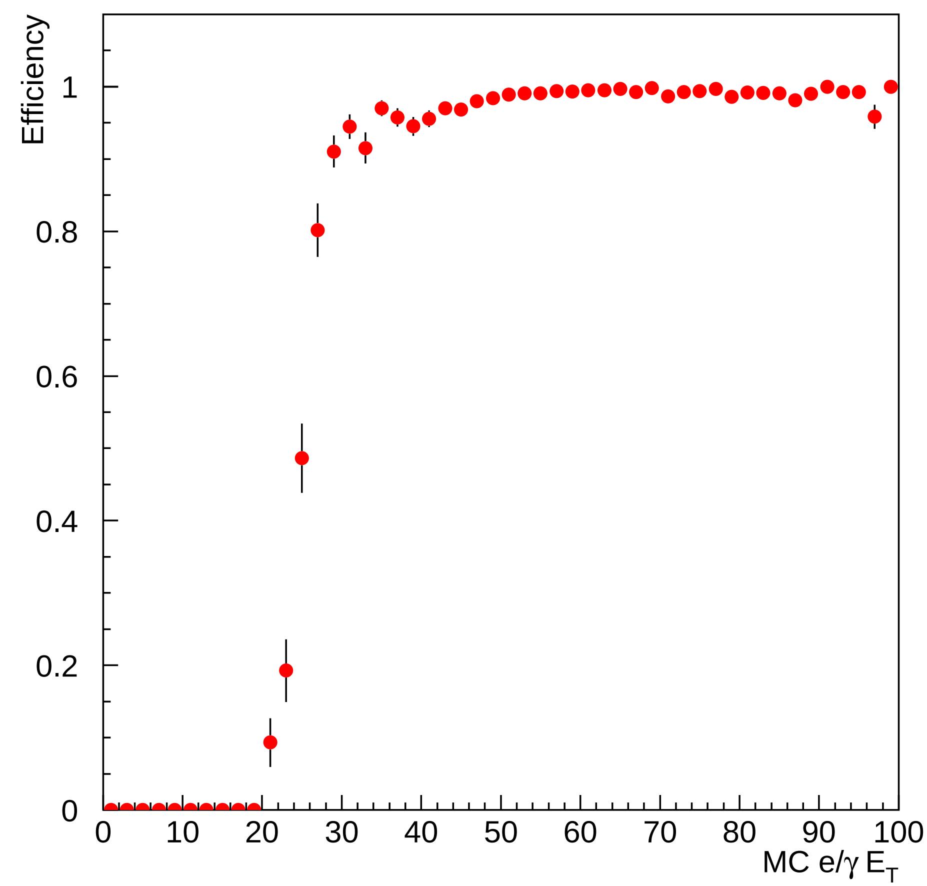
- top 4 τ-jets and top 4 jets in central rapidity, and top four jets in forward rapidity

Updated e/γ rates and single e efficiency

Low Luminosity e/γ trigger rates



Single e/γ Efficiency



Single e/γ at 25 GeV cutoff: 1.9 kHz and 95% efficiency at 31 GeV

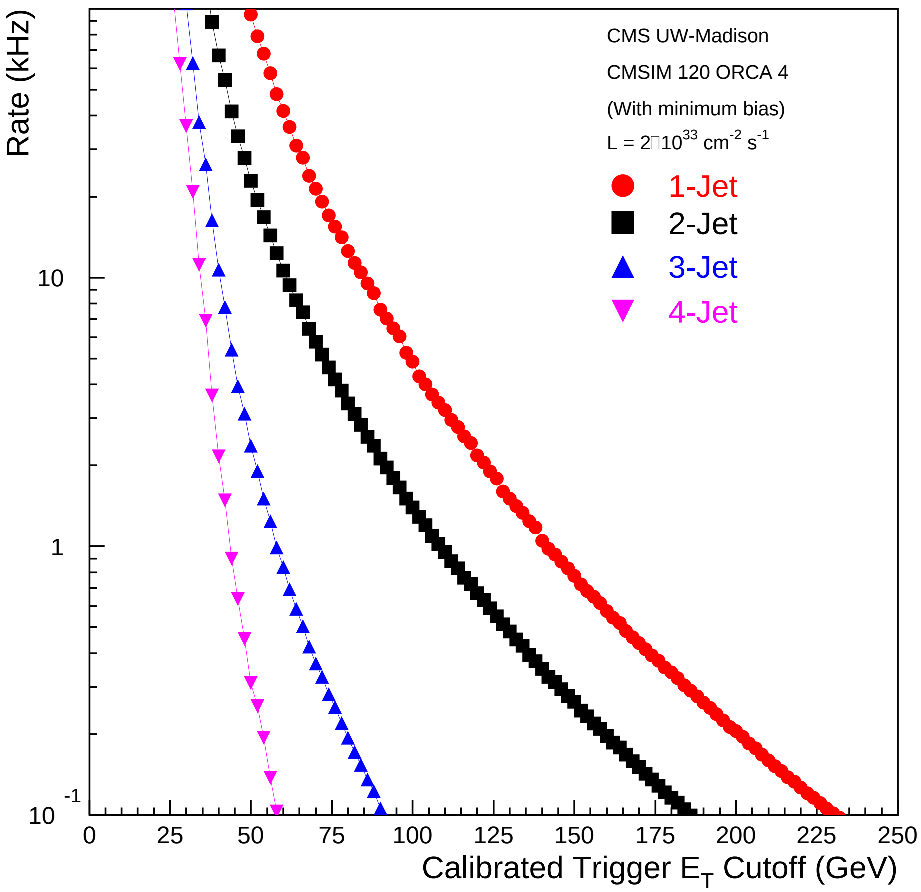
Single e/γ rate from CMS IN-2001/042 **for a 27 GeV Cutoff:**

1.7 kHz (used old 10^{33} data) and 95% efficiency at 32 GeV

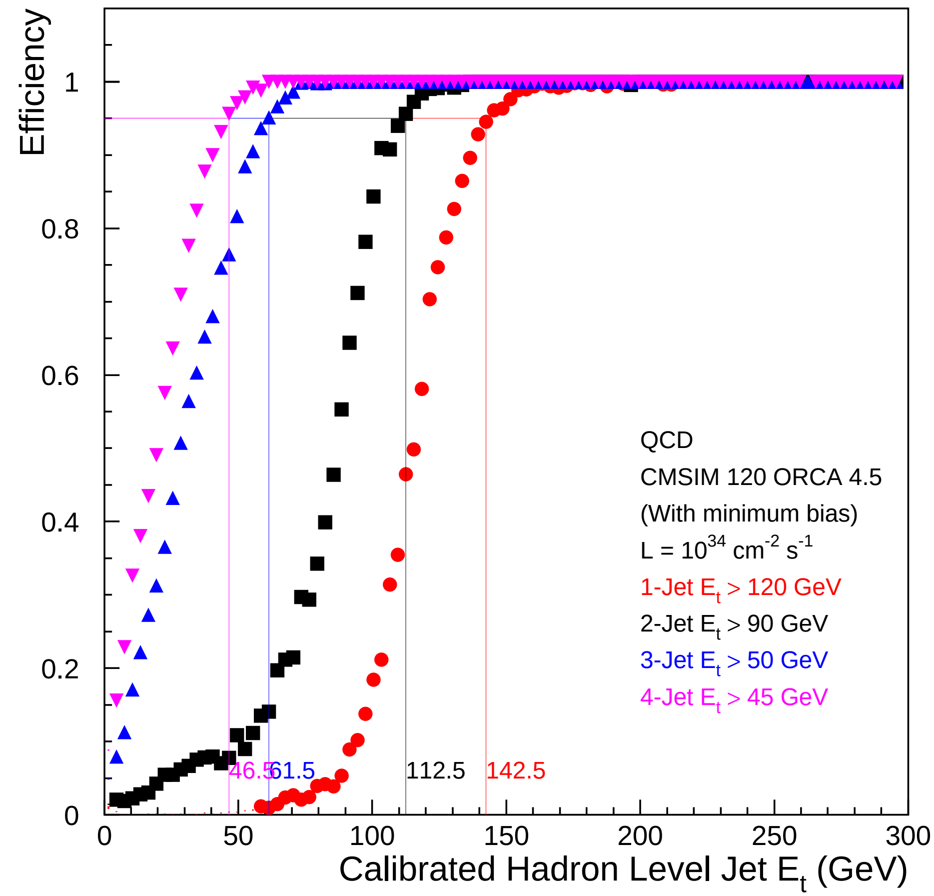
Consistent with TDR result for low luminosity.

Updated Jet Rates and Efficiencies

Low Luminosity Jet Trigger Rates (|η|<5)



QCD Jet Efficiency |η|<5



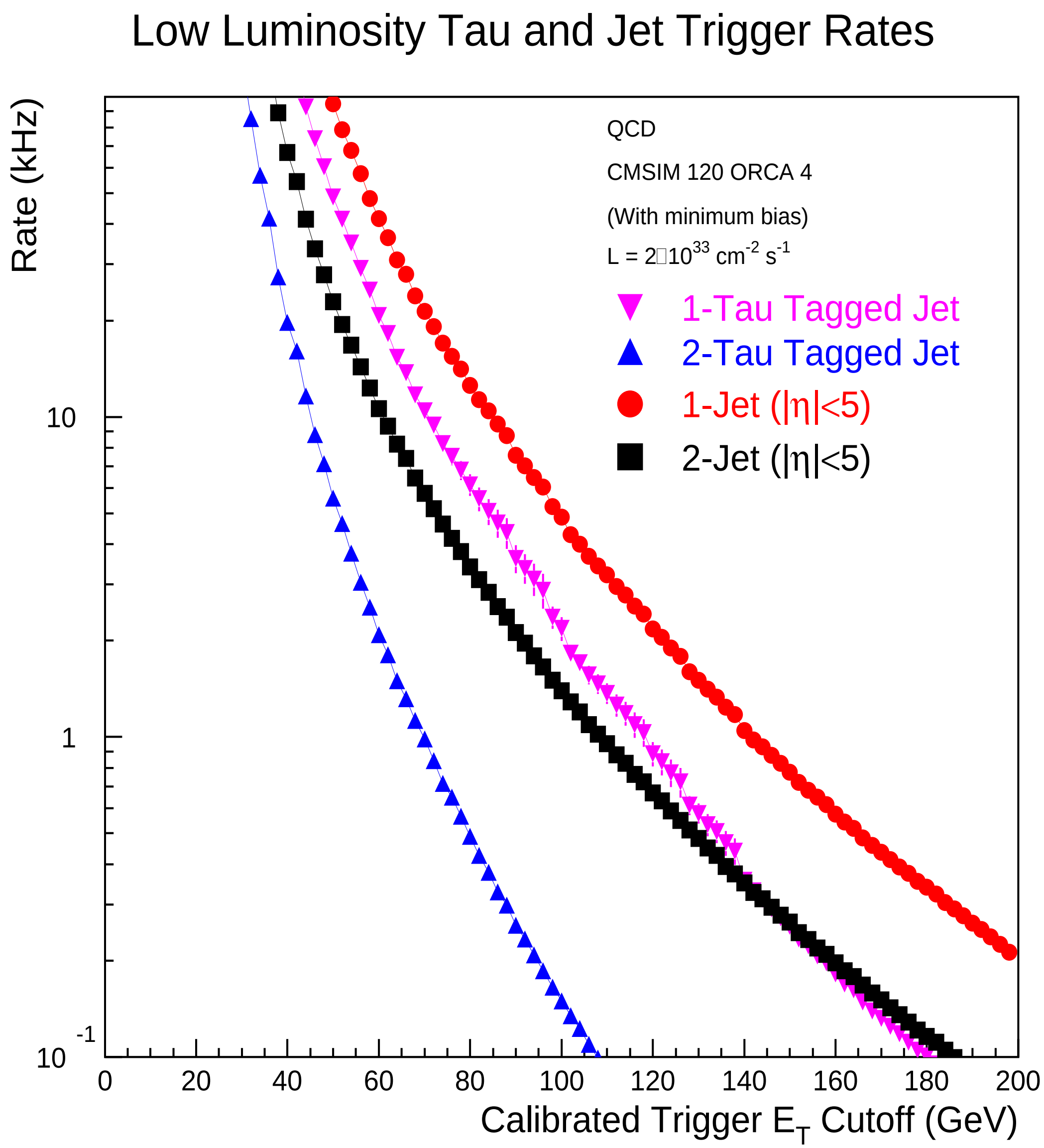
Single jet at 120 GeV: 2.2 kHz and 95% efficiency point = 143 GeV

Dijet at 90 GeV: 2.1 kHz and 95% efficiency point = 113 GeV

CMS IN-2001/042 **w/10^{33} data weighted to 2×10^{33}:**

2.4 and 2.0 kHz and 95% efficiency points are 150 GeV and 115 GeV

Updated τ Rates



Single τ at 80 GeV: 6.1 kHz
Single jet at 120 GeV: 2.2 kHz
Using new τ trigger!

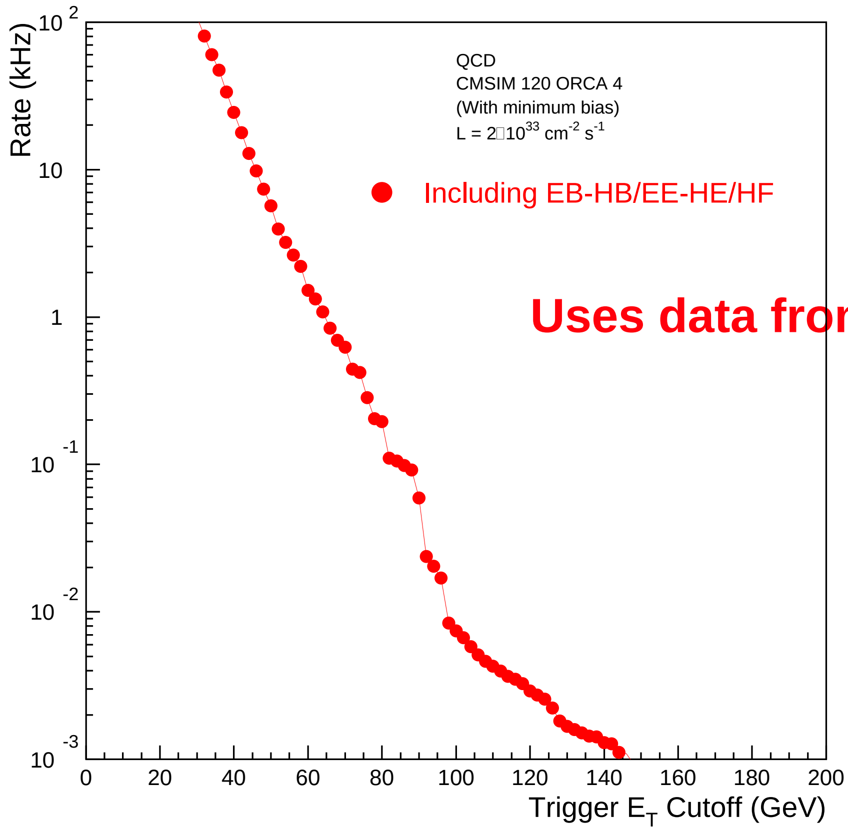
Note w/10^{33} data weighted to 2×10^{33}:
Single τ at 80 GeV: 6.5 kHz
Single jet at 120 GeV: 2.4 kHz

Small differences: single τ rate smoother, rate lower than the results from the note.

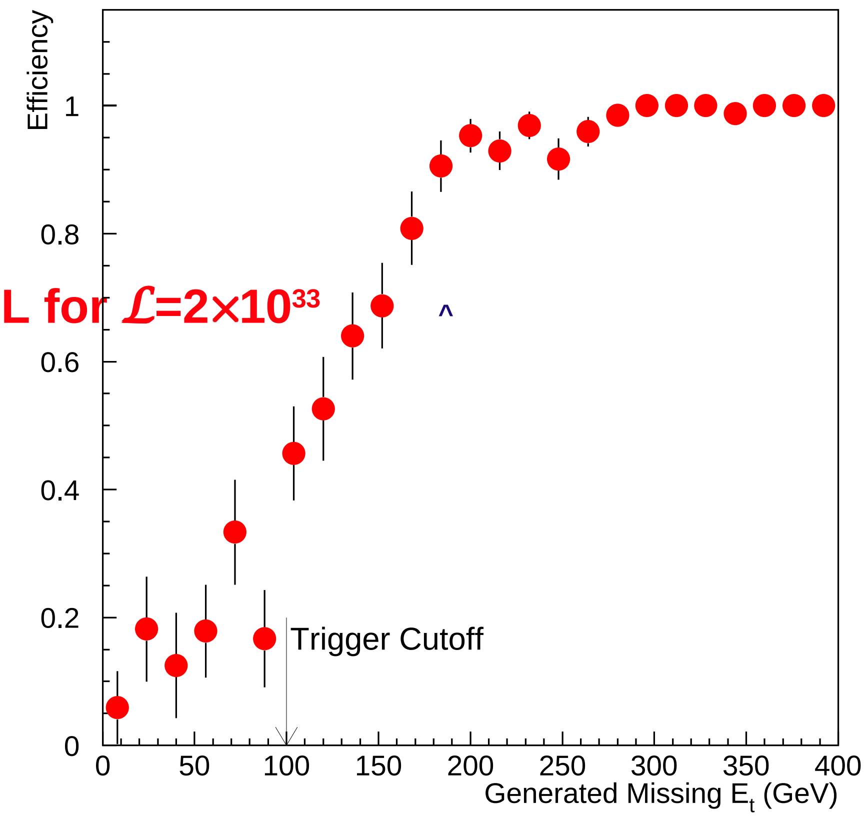
Uses data from FNAL for $\mathcal{L}=2\times10^{33}$

Updated Rate of Missing E_T and efficiency

Missing E_T trigger rate



jm_msugra3 Missing E_t Efficiency



Uses data from FNAL for $\mathcal{L}=2\times10^{33}$

Missing E_T at 100 GeV: <0.01 kHz

Note w/10^{33} data weighted to 2×10^{33}: 0.02 kHz

A data sample was excluded due to a unphysical events of Missing ET~140 and 250 GeV in the 30-50 GeV bin (Excluded from all results)

No real changes in rate vs. previous results. TDR at 0.01 kHz for 10^{33}

However, Efficiency turn on much sharper - 95% efficiency reached at 200 GeV vs 90% at 275!

No calibration is used yet - coming soon.

New Trigger "H_T"

Use all 12 jets: 4 each of central, τ, and forward

- all jets are mutually exclusive

After correcting the jet energies, sum up E_T's of all jets with energy greater than a certain threshold:

- $H_T = \Sigma E_{Tjet}$ E_{Tjet} > threshold energy

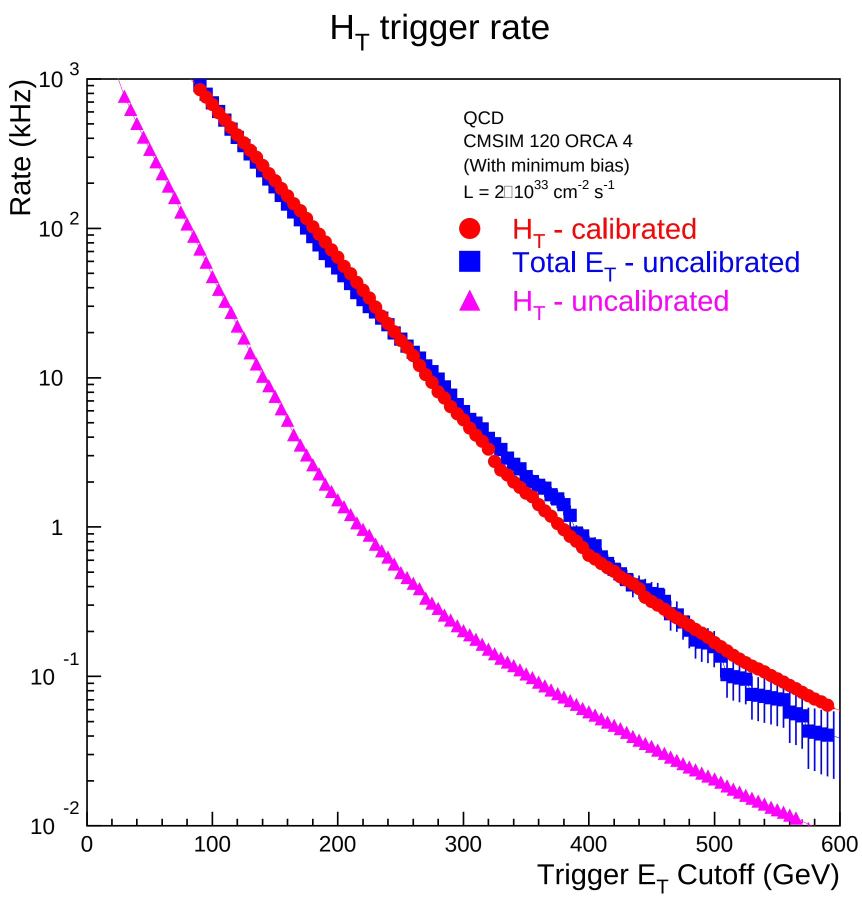
Advantages

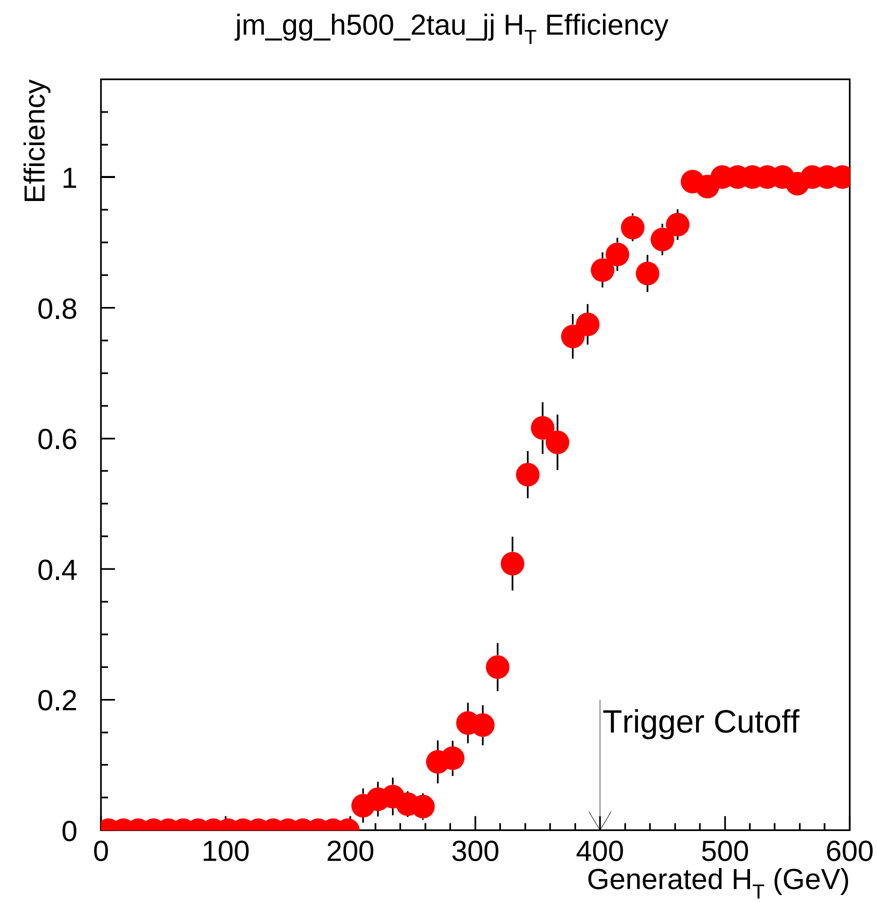
- Calibrated (jet energies are calibrated)
- Simple trigger for decays of heavy objects to multiple jets

New H_T Rate

H_T=sum of all jet E_T's with E_T > some programmable threshold

- **E_T > 10 GeV for this result**





For a 400 GeV cutoff: Rate = 0.7 kHz and 95% eff = 470 GeV

Nice sharp turn on.

Uses data from FNAL for $\mathcal{L}$=2×10^33

Trigger performance explored using new data with 2×10^{33} pileup

Five scenarios for DAQ rate limits from 25 to 100 KHz

- **12.5, 10, 8, 6, and 4 kHz total calorimeter trigger rate limits**
  - Rates adjusted to give emphasis to jet and combined triggers without compromising electron based channels

Three scenarios for a 50 kHz DAQ limit (as suggested by the PRS Group) based on 16 kHz total trigger rate limit (50 kHz÷3 safety factor)

- **Scenario 1: 4 kHz e/ee, 4 kHz jets and τs, 4 kHz μs and 4kHz combined triggers - split between calorimeter and muon triggers**
  - 10 kHz for calorimeter (4e,4j,2c)
- **Scenario 2: 5 kHz e/ee, 5 kHz jets and τs, 5 kHz μs and 1 kHz combined**
  - 10.5 kHz for calorimeter (5e,5j,0.5c)
- **Scenario 3: 4 kHz e/ee, 7 kHz jets and τs, 4 kHz μs, and 1 kHz combined**
  - 11.5 kHz for calorimeter (4e,7j,0.5c)

Following Slides:

- **10 kHz and PRS Scenario 3 corresponding to a 50 kHz DAQ**

Efficiencies for e/γ Channels: Total Calorimeter Trigger Rate=10 and 11.5 kHz

Channels used for efficiencies were generated at FNAL and Wisconsin.

Total Trigger Rate		10.4 kHz		11.7 kHz	
Channel	**Triggers**	**Efficiency**	**Thresholds**	**Efficiency**	**Thresholds**
$W \rightarrow e\nu$	e	60%	25	69%	21
$t \rightarrow eX$	e,e•τ,τ,jjj,e•j	90%	25,15•70,80,60,15•100	92%	21,10•75,85,60,10•100
$Z \rightarrow ee$	e,ee	93%	25,13	94%	21,15
$H(115) \rightarrow \gamma\gamma$	e,ee	98%	25,13	99%	21,15
$H(150) \rightarrow WW \rightarrow e\nu X$	e,e•τ,τ,e•j,j	82%	25,15•70,80,15•100,120	86%	21,10•75,85,10•100,110

Many of the physics channels show efficiencies above 90%.
e and ee triggers include a non-isolated electron cutoff above 45 and 25 GeV respectively.
10.4 kHz is the 10 kHz total trigger rate: more emphasis on jets and combined.
11.7 kHz is with 4 kHz e/ee, 7 kHz jets and τs, and 0.5 kHz combined (3rd PRS scenario).

11.7 kHz does better - mainly due to lower single e threshold.

Efficiencies for jet and τ Channels: Total Calorimeter Trigger Rate=12.5 and 10 kHz

Total Trigger Rate		10.4 kHz		11.7 kHz	
Channel	**Triggers**	**Efficiency**	**Thresholds**	**Efficiency**	**Thresholds**
H(135)$\to\tau\tau\to$ej	e,e•τ,e•j,τ,j	77%	25,15•70,15•100,80,120	83%	21,10•75,10•100,85,110
Charged higgs (200 GeV)	τ,j,j•MET	99%	80,120,60•60	99%	80,110,60•60
H(200)$\to\tau\tau\to$jj	τ,$\tau\tau$,j,jj	89%	80,75,120,95	87%	85,75,110,90
H(500)$\to\tau\tau\to$jj	τ,$\tau\tau$,j,jj	99%	80,75,120,95	99%	85,75,110,90
t$\to$jets	HT,jjjj,jjj,jj,j	64%	400,55,60,95,120	70%	400,50,60,90,110
mSUGRA (pt. 3)	j	99%	120	99%	110
H(120)$\to$bb	jjj,j,τ,jj	52%	60,120,80,95	52%	60,110,85,90
Invisible higgs (120 GeV)	j•MET,j,τ	46%	60•60,120,80	46%	60•60,110,85

Many of the triggers show efficiencies above or near 90%.

e trigger includes a non-isolated electron cutoff above 45 GeV.

Some have a lower efficiency than are in the CMS IN-2001/042 - a bug found in our nTuple Generator was not zeroing the jet energies properly.

10.4 kHz is the 10 kHz total trigger rate: more emphasis on jets and combined triggers.

11.7 kHz is with 4 kHz e/ee, 7 kHz jets and τs, and 0.5 kHz combined (3rd PRS scenario).

11.7 kHz does a bit better than 10.4 kHz - combined with e/γ results$\to$ best combination to get the physics

Summary

Rates for $\mathcal{L}=2\times10^{33}$ cm^{-2} s^{-1} calculated:

- **No significant rate changes due to changes in algorithms**
- **Proper weighting dramatically reduces rates for most channels**
  - p_T's of pileup events were greater than QCD physics event.
- **Results are consistent with earlier TDR results**
- **Thresholds retuned for different DAQ staging scenarios of 12.5, 10, 8, 6, and 4 kHz**
- **3 new PRS Scenarios evaluated and thresholds tuned**
- **Optimized for physics performance**
- **Favorite scenario: PRS #3 with 11.5 kHz target rate (4/7/0.5 kHz of e/j/combined)**
- **Note ready: http://cmsdoc.cern.ch/~pamc/Trigger2e33-03-02.pdf**
  - Supersedes **CMS IN-2001/042**
  - proper weights
  - 3.5 pileup events per interaction
  - more detail on efficiencies